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Identifying past beer production: contribution from an ethno-archaeological study of beer houses and hearths in the Bedik country (Senegal)

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Abstract

The identification of beer production in archaeology remains a major challenge as this activity leaves very little evidence, that is moreover difficult to interpret. To contribute to bypassing this bottleneck, we undertook an ethno-archaeological study of the places of beer production in South-Eastern Senegal. We documented 14 beer houses and several beer cooking areas in 5 present-day Bedik villages and excavated a beer house and beer cooking area in a recently abandoned village (Eguong). The architectural characteristics of these structures were recorded. Pottery found in association with them was also analyzed, combining typometry and use-wear. Such an integrated study has highlighted that the inner layouts of beer houses and some pottery types are relevant criteria for identifying beer production. An examination of these criteria among other African cultural groups supports these results. It shows how difficult it can be to recognize such places in archaeology and encourages further investigations.

Key words: Sorghum beer, architecture, pottery, morphometry, use-wear, Senegal

1. Introduction

The identification of beer production in archaeology is a topic of high interest which transcends cultural contexts (Arthur 2022). In the Nile valley, the importance of beer is attested from the Predynastic period in the 4th millennium BCE, based on archaeological discoveries made at several sites - of which Hiérakonpolis, where the earliest evidence of large-scale beer production has been found around 3600 BCE (Farang et al. 2019). Written and iconographic ancient Egyptian sources, recently supported by organic residue analysis of pottery, contribute to a more and more detailed knowledge of the beer recipes in the past (Farang et al. 2019; Heiss et al. 2020; Wang et al. 2021).

However, ancient evidence of beer production is still scarce in Sub-Saharan Africa outside the Nile valley for several reasons. First, it remains difficult to identify in the archaeological record. Some archaeologists have suggested an increase of beer production from the mid first millennium CE in the Diamaré (Cameroun) by drawing a parallel between the shape of archaeological pottery and present-day ceramic vessels linked to beer production (Langlois 2005). Similar comparisons have been made to prove the production of beer in Kirikongo (Burkina Faso) during the period dated 100-1650 CE (Dueppen and Gallager 2021). However, no residue analysis has been conducted so far on sub-Saharan archaeological pottery assemblages in search for fermentation biomarkers.

Second, written sources are rare and rather recent in Sub-Saharan Africa. Some historians analyzed the few Arabic written sources, dated from the 10th c. CE, in which the consumption of beer is mentioned among the Zaghawa in Tchad, as well as in the Ghana and Mali kingdoms (Cuoq 1985). Thereafter, information can be found in European accounts by travelers or missionaries since the 17th c. CE, and finally in studies made by social anthropologists among various African societies during the 20th c. A comprehensive study of historical dynamics of beer around Lake Tchad details the content of these sources (Berger 2022).

All the studies, led by archaeologists, historians, and social anthropologists, have shown the importance of beer in the social, economic, and religious organization of non-Muslim societies and give an idea of the diversity of recipes and ingredients, including cereals like millet, sorghum and more recently maize in the savannas, and various tubers or legumes in the tropical forests. Its production takes place in specific locations, lasts several days, and involves various containers, namely ceramic vessels used for cooking, fermenting, and serving the beverage. Beer is strongly rooted in these societies, often organized for collective celebrations, and part of rituals (Jolly 2004; Berger 2022).

However, few ethno-archaeological studies (Arthur 2002, 2003) have focused precisely on the question of the recognition of beer materiality and spatiality, despite its high interest in reconstructing the history of this largely distributed human practice. This is an issue as beer production using traditional recipes and vessels made from local materials such as pottery, basketry and calabashes is quickly disappearing, challenged by the progression of Muslim religion, growth of industrial beers, replacement of local containers by imported ones in metal or plastic, and general loss of pottery manufacturing or beer production know-how. We are thus facing on one hand a lack of systematic ethnoarchaeological reference linking material culture and beer production, and on the other hand the urgency to build such an interpretative reference.

Ethnographic investigations may help establish diagnostic criteria for the interpretation of beer production in archaeology. However, post-depositional mechanisms can blur the signal, and complex local evolutions make the analogies more difficult to establish when the chrono-cultural

distance is important. Projects endorsing a methodology combining both ethnographic investigations and the excavation of recent contexts (Arthur 2021) have the potential to precise the archaeological expression of beer production, to question the preservation of material culture and to highlight past know-how, as well as social and ritual aspects.

In this manner, our ethno-archaeological study aims at exploring the question of the identification of the places of beer production in the African past. What sets a beer house apart from the other types of buildings? Does it stand out in terms of architecture and pottery? To answer these questions, an ethnographic study was carried out in several Bedik villages located in South-Eastern Senegal, a region where beer production is strongly rooted in the society. The architecture of the beer houses, locations of the production stages, and pottery types related to beer production were documented. An archaeological excavation was also conducted on the site of Eguong, a Bedik village abandoned in 2009. The architecture of the collapsed beer house, as well as the fragmented pottery assemblage from the site were documented following the same approach. Given the temporal and spatial proximity of these contexts, direct analogies could be made. Cross-cultural validity of the diagnostic traits for identifying the places of beer production in Bedik villages are finally discussed in comparison with their expression in other beer-making groups from western, eastern, and southern Africa.

2. Bedik society and beer

2.1. Environmental and cultural contexts

The Bedik country lies in South-Eastern Senegal, between the regional capital of Kedougou to the West, the border with Guinea to the South and Niokolo Koba Park to the North. It is bounded by the Gambia River and one of its tributaries, the Tiokoye, and by the last foothills of the Fouta Djallon Mountain (Fig. 1). It forms part of a wider area designated a UNESCO World Heritage Site in 2012 under the title “Bassari cultural landscapes”, including territories also inhabited by the Bassari, Fulani and Djalonke people (Bocoum and Moriset 2012). The territory inhabited by the Bedik is around 300 km², located in the administrative *arrondissement* of Bandafassi. This area is characterized by a wooded savannah, home to many varieties of useful trees and plants well known to the local communities, as well as a large range of wildlife, strictly protected in the Niokolo Koba Park.

The Bedik people speak the Menik language, which is subdivided into two main dialects, *Banapas* and *Biwol*. Their ethnogenesis has developed over the last few centuries, through migrations from the Mali empire (13th-16th centuries) and the aggregation of Keita and Kamara clans, including Samura, Sadiaxu and Kante families, each of which is characterized by a particular power or knowledge. Thus, the Keita are the political chiefs, the Sadiaxu are the religious chiefs, the Kamara play the role of their adjuncts, assistants or intermediate organizing ceremonies, and the Samura and the Kante are the blacksmiths (Gomila and Ferry 1966). However, unlike neighboring societies, Bedik society is not structured into endogamous castes. Alliances and craft activities are therefore freely chosen. For example, any woman can make pottery or spin cotton, and any man can make basketry or leather items.

The territory occupied by the so-called Tenda populations (including the Bassari and Bedik people) was previously much larger than today, but following the insecurity engendered by the slave raids of the Islamized Fulani of Fouta Djallon in the 19th and early 20th centuries, the Bedik mainly settled in refuge villages perched on rocky reliefs (Ethwar, Andiel, Iwol, Ethiès), connected to

caves used as hiding places in case of attacks. As the 20th century progressed and the region was pacified, the temporary farming hamlets on the plains became permanent villages (Ferry 1967). While some highland villages, such as Iwol and Ethiès, are still well populated, the village of Ethwar was completely deserted in May 2023 (personal observation), in favor of the lowland hamlets of Bagnang and Indar. It is now frequented only for the ceremonies and initiations that punctuate the Bedik annual calendar, and for collecting wild plants in the surroundings.

The Bedik are growers of domesticated cereals (sorghum, fonio, corn), rice and tubers (peanuts, yams, groundnuts), as well as legumes and spices for sauces (onions, okra, Guinea sorrel, chilies). They also collect numerous wild tubers, leaves, fruits, nuts and mushrooms for food, handicrafts, and medicine. Traditionally, the Bedik are hunters and eat the meat from various wild animals, such as warhogs, monkeys, antelopes, and mongooses. They also collect honey. These practices are tending to disappear with hunting bans and the decline of flowering trees. The few domestic animals present in the villages, such as cows, goats, and poultry, are mainly used for sacrifices during ceremonies, feasts, and funerals. Today, the Bedik people nearly all claim to be Christians, but remain intimately linked to their ancestral religion.

2.2. Context of beer production and consumption

Socio-economic and symbolic context of beer consumption

In the Bedik country, beer (*Ungotyin*) is not a secular fermented beverage drunk daily, as is the case of palm wine. It is only consumed during the dry season for ceremonies linked to feasts and during the rainy season for collective work in the fields accompanied by masks. Beer is produced six or seven times a year for feasts linked to the agricultural calendar: when the millet begins to ripen (November), when it is possible to burn the grass around the villages (December), and at the end of the harvest (end of December), as well as for feasts linked to the circumcision (March), the initiation of young circumcised men (April) and the women's festival (May). In addition, each family makes beer for at least two collective works, one to cultivate the woman's fields and another one to cultivate the man's fields. The frequency of beer production can therefore be estimated at around ten times a year, all linked to ceremonies.

Beyond its obvious symbolic dimension, beer production has a huge impact on the socio-economic system of the Bedik society. In March 2022, ethnographic survey was conducted in the village of Iwol (618 inhabitants in 2022) while beer was being prepared for the circumcision feast. Interviews carried out with the inhabitants have allowed us to estimate the ratio between sorghum for beer and sorghum for food per year. To produce beer for the six annual feasts and a few collective field works, a medium-size family uses from 265 to 465 kg of sorghum, depending on whether it has a young, circumcised boy to initiate. In addition to other cereals and tubers (500 kg of corn, 200 kg of fonio, 1000 kg of groundnuts, and 50 to 100 kg of rice, depending on means), the family needs 500 kg of sorghum a year for food. These data tend to show that almost half a family's sorghum harvest can be spent to make beer. Beer production mobilizes therefore an important part of the sorghum production.

Ethnographic survey has also allowed us to assess the volume of beer produced for the circumcision feast organized in March 2022. Eight Keita, Kamara, and Samura families, comprising one to three circumcised boys aged 14 to 16, cooked between 800 and 2400 liters of malt, and at least three families without circumcised boys prepared a 200-liter barrel each on a voluntary basis, to help. Two sessions of beer were made a day apart, to have enough to drink for the whole three-day feast, bearing in mind that consumption must take place within 2 to 3 days after fermentation. Thus, at least 9245 liters of malt were boiled, mostly in 200-liter metal barrels, but can be estimated to amount a total of 10 '000 liters knowing few barrels were likely not

observed. After two boiling and filtering processes (see below), we have measured that 400 liters of malt result in 170 liters of ready-to-drink beer, i.e., a reduction more than half in volume. A quick calculation shows that around 4250 liters of beer were served in Iwol to the inhabitants of the village (men, women, and children), as well as to guests coming from other Bedik villages for this feast, which means an enormous economic effort for enhancing social cohesion.

Spatiality and materiality of beer production

Beer-making takes place in three different areas of the Bedik compound: The open-air courtyard located at the center of the compound; the beer house, situated among the other circular buildings; and a large hearth that is often located in the outskirts of the compound (Fig. 2).

The courtyard usually accommodates a variety of food activities (including preparing, cooking, and eating meals as well as making beer) and handcraft activities (like manufacturing pottery or basketry). No structure linked to beer production is arranged in this space.

The beer houses are usually part of a compound inhabited by an extended family and contain various calabash and pottery vessels related to beer production that may belong to the head of the compound or to different family members (Fig. 3; Tabl.1). Although the ownership of the vessels is known and claimed, beer production is always shared. If a family does not own a beer house, they may give their sorghum to neighbors and the resulting brew is shared. Although large pottery vessels are mostly static due to their size, weight, and the nature of their use, they occasionally move places, are lent, or taken out for refurbishing. Beside pottery vessels, some beer houses hold an altar inside, composed of special stones and specific pots, such as a highly decorated 8-shaped bottle (*Kopoot*) or globular pot and a plain hemisphere sometimes associated with a small ceramic lid. A beer house without such a ritual place could never acquire one, as these cannot be displaced. Finally, there are some beer houses without any pottery inside, only used for specific celebrations. The village of Iwol holds for example an empty beer house dedicated to women (*Olo*), and another to men (*Owod*), used respectively during women and men feasts, which do not occur every year. For these occasions, beer vessels are borrowed from Kamara families as they are responsible for rituals.

Although the material culture found inside is overwhelmingly associated with beer production, our investigation also highlighted the versatility of some beer houses, even as the owners insisted on the fact that it was an exceptional occurrence. One beer house was full to the roof with cotton flowers as the harvest was bountiful and the family granary was already full, and no beer was to be produced in the meantime. Another had a built-in mezzanine used to store grains and peanuts and served simultaneously as a granary. Overall, most beer houses were used in parallel with the main beer production activity, to store a bag of grain, tools, or shelter the material for an ongoing activity that would be resumed later (food preparation, pottery manufacture, weaving etc.). In addition, all the 14 beer houses were opportunistically used as a haven by animals, and their presence was tolerated by the beer house owners. Brooding hens and nursing dogs were frequent, and some animals also chose the calm of the place to die. This resulted in cadavers of chickens that could easily be confused with the remains of sacrificed roosters found atop the altar.

Hearths used for boiling malt are located a few meters apart from the compounds. They are light structures composed of three large stones with no flooring or superstructure. Large vessels are typically left on top of three large stones all year long but can also be turned on their rim and brought back to the compound. These large hearths can also be used to prepare soap, in a vessel used specifically, as soap too requires long cooking sessions.

2.3. Beer-making among the Bedik

The “chaîne opératoire” of Bedik beer was mainly documented in the village of Iwol in March 2022. Observations were completed in Indar in July 2023.

Ingredients and utensils

The following ingredients are necessary to make 340 liters of beer: 200 kg of cereals (mainly sorghum, but millet and maize can be mixed), and 800 liters of pure water coming from boreholes.

Beer-making requires the use of a wide variety of kitchen utensils and containers, including:

- Ceramic vessels that can be divided into three main types: 1. slightly closed shapes of medium to large size (between 65 and 150 liters) with a pointy base (*Atieda*); 2. slightly closed shapes with a very large to large capacity (over 100 liters) with pointed base (*Elema*, *Nianema*, *Nietede*, *Atwagn*); 3. very closed shapes of small to medium size (from 2 to 10 liters) with round base (*Niene*, *Ide*, *Amband*).

- Utensils in other materials: calabash bowls and ladles, wooden mortars, and pestles as well as sticks, mats, basketry, and filters mainly made from palm leaves, and recently metal barrels, and plastic basins and cups.

The introduction of metal and plastic containers is recent, they tend to supplement some more traditional calabash or pottery containers and sometimes replace them entirely depending on the function. Beer, for instance, is traditionally consumed in calabash bowls used specifically for this purpose; today, these containers tend to be supplemented but not replaced with plastic bottles and cups. Similarly, beer is traditionally cooked inside large ceramic vessels (*Atieda*); today, this functional type is frequently replaced with metal barrels which have a better heating efficiency while being more resistant to thermal and mechanical shocks.

Contrarily, some functional types of pottery like the large conical vessels (*Elema*, *Nianema*, *Atwagns*) and small globular vessels (*Niene*, *Ide*, *Amband*) used for fermentation cannot be replaced by vessels made from other material, because of the performance of the clayey material for trapping yeast in the porous walls. The large beer pots are known to be difficult to manufacture and expensive, but they are never replaced by metal barrels, because these containers appear to be unsuitable for fermentation. *Elema* are instead replaced either by new ones, or by reused old large *Atieda*.

Preparation time and procedure

Beer-making among the Bedik is a complex process that lasts around 10 days. It is made following three main stages: malting, brewing and fermentation (Fig. 4).

STAGE 1. The malting consists of preparing the grains for the chemical reactions that will enable the starch contained in the cereals to be saccharified (Jolly, 2004). It is carried out in six main phases (Fig. 4a):

Phase 1.1. 150 kg of sorghum grains are winnowed in the courtyard to remove the small part of grains unsuitable for beer-making.

Phase 1.2. The winnowed sorghum grains are soaked for 1 day in *Elema*-type pots inside the beer house.

Phase 1.3. The soaked and winnowed sorghum grains are filtered using a fine mesh net placed above a palm-tree leaf basket. They are then distributed among several *Elema* and baskets inside the beer house and left to dry for 2 to 3 days. The grains start to germinate.

Phase 1.4. The germinated sorghum grains are put all together in the *Elema* and left to dry for one extra day inside the beer house.

Phase 1.5. The germinated sorghum grains, so-called green malt, are spread out on a mat in the courtyard and left to dry in the sun for 1 to 2 days.

Phase 1.6. The dried germinated sorghum grains are pounded using wooden mortars and pestles in the courtyard. The flour obtained is then spread out on a mat and left to dry in the sun for 3 to 4 hours. Once dried, it is winnowed to remove the coarsest particles (fragments of partially crushed grains, etc.).

STAGE 2. The brewing aims to obtain a fermentable wort after solubilizing the malt flour and transforming the starch (Jolly, 2004). It is made into nine main stages (Fig. 4b):

Phase 2.1. Around 30 liters of germinated sorghum flour + 120 liters of water are poured into the *Elema* inside the beer house. The two ingredients are then mixed with the arm to avoid the forming of lumps.

Phase 2.2. The supernatant, concentrated in the upper two thirds of the *Elema*, is transferred directly into plastic basins (formerly large calabashes), using calabash bowls. The deposit located at the bottom of these large vessels is filtered using a palm-tree leaf basket. The liquid extracted from the spent grains is then collected in plastic basins and mixed with the supernatant previously collected. The spent grains trapped into the filter are kept and dried before being pounded into flour and used in the preparation of daily meals.

Phase 2.3. The mixture of germinated sorghum flour + water that was filtered is then boiled in metal barrels (formerly in *Atieda* pots). It is stirred from time to time using a palm-tree branch or a large wooden stick. This phase, carried out in the cooking area, lasts between 8 and 10 hours.

Phase 2.4. The mixture of germinated sorghum flour + water that was filtered and boiled is then cooled in the *Elema* inside the beer house. The cooling process lasts 24 hours. At this stage, the starch contained in the cereal grains is saccharified.

Phase 2.5. At the same time, 50 kg of ungerminated sorghum grains are pounded using wooden mortars and pestles until flour is obtained that is then sieved. The whole process takes place in the courtyard.

Phase 2.6. The mixture of germinated sorghum flour + water that was filtered, boiled and cooled is then filtered using a small basket inside the beer house. The spent grains will be thrown or kept feeding the animals.

Phase 2.7. 50 kg of ungerminated sorghum flour is mixed with water coming from the rinsing of the filtered spent grains until it becomes a thick paste. This phase takes place in the courtyard.

Phase 2.8. At the same time, the liquid mixture of germinated sorghum flour + water that was filtered, boiled, cooled, and filtered is boiled in the metal barrels (formerly in *Atieda*). After cooking for two hours, the thick mixture of ungerminated sorghum flour + water is added. The two components are strongly stirred together using a palm-tree branch or a large wooden stick to avoid the forming of lumps. This phase, carried out in the cooking area, also lasts between 8 and 10 hours. At this stage, the wort is obtained.

Phase 2.9. The content of the metal barrels is poured into the *Elema* inside the beer house and left to cool for 6 to 7 hours.

STAGE 3. The fermentation consists of transforming the fermentable sugars into alcohol using yeast (Jolly, 2004). In the Bedik society, the process takes place in three phases (Fig. 4c):

Phase 3.1. Around 30 liters of the liquid (or 'wort') cooling in the *Elema* is transferred to a plastic basin. Two large handfuls of dried germinated sorghum flour are then added, and the mixture is stirred for a long time until it is lukewarm. Once cool, the 'wort' contained in the plastic basin is distributed into the *Niene*-type pots, where active yeasts from previous fermentations have been preserved in the porous inner walls of the ceramic vessels. Fermentation only takes place 3 to 4 hours after the 'wort' is transferred to the pots.

Phase 3.2. Between 3 and 5 liters of fermented beer from the *Niene* are then poured into the *Elema*. Two large handfuls of dried germinated sorghum flour are added to the contents of these very large vessels. The mixture is stirred until it is homogeneous. Fermentation takes place within 6 to 7 hours.

Phase 3.3. Once fermented, the beer is filtered again before being poured into *Niene* or plastic cans (formerly large calabashes with a restricted mouth) and transported for consumption. It is drunk in calabash bowls, or now sometimes in plastic cups.

3. Material and methods

3.1. Ethnographic investigations

An ethno-archaeological study focused on the use of pottery and food habits of Bedik societies was carried out by Anne Mayor and Julien Vieugué from 2016 (Mayor and Vieugué 2017). More than 120 ceramic vessels from different functions - including pots used for roasting cereals or tubers, boiling cereals, and sauces, steaming cereals or shea nuts, boiling, cooling, and fermenting beer, storing, and transporting water, etc. - were systematically documented. In parallel, fieldwork focused on the present-day Bedik vernacular architecture was conducted by Thomas Pelmoine (Pelmoine 2020; Pelmoine and Mayor 2020). 7 compounds - comprising 55 bedrooms, 9 granaries and 5 beer houses - were precisely recorded. Benefiting from both previous studies, a comprehensive study targeting the structures and utensils related to beer production in the Bedik country has been undertaken by Pauline Debels in 2022-2023. 14 beer houses and 164 associated beer pots, as well as several hearths and 6 beer cooking pots were studied.

Beer houses

The 14 beer houses, selected for study based on voluntary participation of their owner, come from 14 different compounds located in five Bedik villages (Ethwar, Andiel, Iwol, Manda Thiès and Ninesha). Eleven of them are from ancestral highland settlements (Ethwar, Andiel and Iwol), while 3 are established in lowland villages (Manda Thiès, Ninesha). The beer houses from ancient and recent villages could thus have been compared to assess their variability in space. Six of the beer houses documented come from the present-day village of Iwol, which is located close to the abandoned site of Eguong (see below). More reliable comparison between present and past could thus have been made. Such sampling strategy has allowed us to provide a first overview of the variability of beer houses among the Bedik communities.

The beer houses were subject to a detailed analysis: Architecture was the first element investigated insofar as architectural remains are found on most of the archaeological sites in Africa. After the building plan was drawn, we recorded four main criteria that are potentially

recognizable in the archaeological record: 1) The location of the beer house inside the compound, 2) the size, 3) the building materials and techniques and 4) the wedging hole of the beer pots. We then focused on the inner organization of beer houses. Every artifact (containers, utensils) and eco facts (plant and animal products), were inventoried and located on the building plan, whether they were directly related to beer production or not. The total surface area of each beer house was calculated, and the ratio of occupied vs free space accounted for. The data collected on the architecture of the 14 beer houses were finally compared to the ones previously collected on the architecture of 55 bedrooms, 9 granaries and 5 beer houses (Pelmoine 2020). Such a comparative approach has allowed us to identify the criteria that might help to distinguish the beer houses from other types of buildings such as bedrooms or granaries.

Ceramic vessels were the second element investigated due to the good preservation of potsherds on most of the archaeological sites in Africa. All the 164 ceramic vessels coming from the 14 beer houses were studied from a morphometric standpoint, except the ritual vessels. Five criteria were recorded: 1) rim diameter, 2) maximum diameter, 3) height, 4) capacity calculated from the drawing of the pots as well as 5) decoration type. In total, 34 of these ceramic vessels (21%), which are representative of the different types of pots involved in the beer production, were then studied using a use-alteration approach. Use-traces were characterized macroscopically and classified into three categories: 1) addition wear (soot deposits, charred residues, lime deposits), 2) subtraction wear (abrasion, clay crumbling, dissolution of carbonates, chipping), and 3) modification wears (reoxidation, cracks etc.). The database used for this investigation also considers the location of use-traces along the profile (inner versus outer rim/upper body/median body/lower body/base, handles and decorative elements) as well as their morphology (punctual, covering, linear, ring shaped). Data collected regarding typometry and use-traces on the 164 beer pots were finally compared to the ones from previous published studies (Arthur, 2002 and 2003; Mayor and Vieugué, 2017). Such a comparative approach has allowed us to determine the criteria diagnostic of beer pots.

Hearths

In addition to the precise documentation of the beer houses, several hearths used for beer cooking were informally looked at in three different Bedik villages (Iwol, Andiel and Ethwar). They have been much briefly documented as only two criteria were considered: 1) The location of the beer hearths; 2) Their global shape. Six beer cooking vessels found close to such specialized hearths were also documented. The same analytical procedure, combining morphometry and use-alteration, was applied to these vessels.

3.2. Archaeological excavation

After surveying the region, we decided to excavate, with the agreement of the chief of the village of Iwol, Jean-Baptiste Syaro Keita, and the descendants of the inhabitants, a recently abandoned ruined Bedik village called Eguong. This village was established close to the preexisting village of Iwol (≈ 1 km), well before the war with Alfa Yaya at the end of the 19th century according to local memory. It was abandoned progressively around the Second World War. Only one compound inhabited by a Sadiaxu family remained occupied until 2009, and the patriarch was a major religious chief (Oral Communication J.-B. Keita). The 2022 archaeological investigation focused on this compound. The buildings and hearths were still visible and functionally identified by J.-B. Keita before any excavation took place. According to the latter, the compound would have been composed of six bedrooms, two granaries and one beer house, a courtyard, and exterior domestic hearths (for food cooking inside the compound and for beer production at the outskirts) as well as

disposal areas and a collective place of palaver at the periphery. Two bedrooms, one granary and one beer house were excavated, while test pits were carried out in the center of the courtyard, two outdoor hearths (including a hearth for beer cooking), the place of palaver and two disposal areas. A total of 49 m² were excavated. In most cases, the archaeological layer was thinner than 30 cm.

A total of 2051 sherds have been uncovered during the excavation, but only 18 vessels could be reconstructed, totaling 68 sherds.

Sadiaxu family's beer house

The beer house was excavated using the planimetric technique and using the opposite square method. In agreement with the inhabitants of Iwol, specific precautions as to not destroy the massive altar found inside were taken. A 21 m² area was implemented to encompass the entire structure and its immediate surroundings, except for the indoor and outdoor altars.

A total of 116 sherds over 5 cm were uncovered inside the beer house, contributing to 10 of the reconstructed vessels. The archaeological pottery was studied similarly to the ethnographic one, using morphometrical and use-alteration criteria, although the method was adapted to the fragmentation of the archaeological assemblage by extrapolating from the sherds the rim diameter, maximum diameter, and height.

Sadiaxu family's beer cooking area

A 1 m² test pit was implemented at the center of the beer cooking area and excavated using the planimetric technique. Unfortunately, no sherd was uncovered in association with the structure.

4. Results

4.1. Spatial distribution and architecture of structures linked to beer production

Ethnographic observations

- Beer houses

In the Bedik country, the beer houses are loosely positioned around the central courtyard of the compound, in the same way as the bedrooms and the granaries (Fig. 5). The location of the buildings is therefore not a relevant criterion to identify the beer houses.

All the beer houses documented are round (14/14), such as bedrooms (55/55) and granaries (9/9) (Fig. 5). The shape of the structures cannot either be used to distinguish the beer houses from other types of buildings.

The beer houses that were recorded are of different sizes, ranging from 3,10 m (= 7,55 m²) to 4,84 m in diameter (= 18,40 m²) with a median at 3,54 m (= 9,85 m²). They tend to be interspersed between the small granaries measuring from 2,10 to 2,61 m (= 3,45-5,35 m²) and the large ones making from 3,80 to 4,05 m (= 11,35-12,85 m²). The beer houses appear furthermore to be slightly

smaller than the bedrooms, the diameter of which ranges from 3,33 m (= 8,55 m²) to 5,20 m (= 21,22 m²) with a median at 4,20 m (= 13,85 m²) (Fig. 6). Interestingly, the extraordinary size of one of the beer houses (Andiel – Syaro Kante; 4,84 m in diameter) can be explained as it is a reassigned building that was once a bedroom. To some extent, the dimensions of the buildings seem therefore to be a diagnostic criterion to differentiate the beer houses from the other types of buildings.

In the Bedik country, most of the beer houses are made of earth walls, built using cob technique (11/14), but some of them are also made of perishable plant material walls (either bamboo or grass), built using wattle technique (3/14). Like beer houses, granaries are made according to both building materials and techniques. Only bedrooms are systematically made of earth walls, built using cob technique (Fig. 7) (Pelmoine and Mayor 2020). The building materials and techniques are therefore barely more informative as only bedrooms show a specific preference for a single technique.

The interior layout of beer houses is generally composed of a plain surface with no second floor and no furniture. The only structures that can be observed are shallow pits lined with stones supporting the pointy base of large vessels used to cool, store and ferment beer (14/14) (Fig. 8). This differs from bedrooms where beds are supported by wooden pillars inserted in the ground, leaving postholes. Similarly, granaries often feature a mezzanine supported by wooden posts stuck into the ground. All pots used to store foodstuff or water in bedrooms or granaries are either put directly on the ground or maintained using wooden posts but never wedged in a pit as was observed inside beer houses. The presence of wedging holes with stones can therefore be another diagnostic criterion for identifying beer houses.

Some beer houses (6 out of 14) include an altar in the form of grouping of stones, sometimes accompanied by specific ritual pots. Such a particular feature, which is most often located inside the building, is totally absent in the bedrooms and the granaries of the Bedik villages. Its presence may therefore indicate that of a beer house.

- Beer cooking areas

The hearths related to beer production are always located on the outskirts of the compounds (Fig. 9), while the ones used for cooking food are consistently located inside the courtyard. The location of the fireplaces can therefore be considered as significant evidence to distinguish the former from the latter. However, caution must be taken because the hearths used for beer production can sometimes also be used for soap making, which requires the same use of large vessels remaining on the fire for several hours.

The hearths related to beer production are composed of three large stones used to stabilize the large vessels, sometimes fitted with sherds. The stone structure is always associated with an ashy patch. The hearths used for food cooking are surprisingly very similar (Fig. 9). No obvious criteria allow us to distinguish them.

In short, the ethnographic study shows that only three criteria allow us to differentiate beer houses from other buildings: the size of the structures, the presence of wedging holes and the presence of an altar. And only one criterion permits to distinguish hearths related to beer production from the ones related to food cooking: their location in relation to the compound.

Archeological data

- Beer house

The beer house uncovered at Eguong is loosely located around the central courtyard of the compound, alongside bedrooms and granaries. It is round shaped, as are the other buildings still visible at the surface of the site (Fig. 10). Its diameter, which is about 4,70m (= 17,35 m²), is surprisingly large compared to the bedrooms which range from 3,56 to 4,78 m (= 9,95-17,95 m²) and that of the granaries which measure between 4,06 and 4,20m (= 12,95-13,85 m²) (Fig. 11). The beer house excavated at Eguong is made of earth walls, most probably built using the cob technique, such as the three other buildings investigated. Two shallow pits of 40 and 30 cm in diameter, fitted with stones, were recognized along the wall in the southern part of the beer house (Fig. 10). Such structures, which likely correspond to the wedging holes for the large beer pots (*Elema*), were not identified in the two bedrooms and single granary investigated. Several post-holes, dug in the substratum, were surprisingly identified at the entrance of the beer house, although it was not possible to determine whether they were part of a layout inside the beer house or linked to earlier occupations. A much larger number of post holes, between 4 and 20 cm deep, were recognized in the 2 bedrooms excavated but none was strangely identified in the granary investigated. However, it should be noted that the substratum was brittle in this area, making the identification of post holes difficult. The most prominent feature of the beer house is the altar structure, taking roughly 40 % of floor space and composed of large slabs on the outside layers and smaller module stones towards the center, as well as metallic elements, and two wooden drums. Such a particular structure was totally absent in the 2 bedrooms and the granary investigated.

The presence of two shallow pits and one altar inside the excavated building are compatible with oral tradition according to which it would have been used as a beer house. On the other hand, the size of the structure does not match with it.

- *hearth used to cook beer*

The hearth used for making beer is located outside the compound investigated at Eguong, quite far from the buildings (about 30 m to the North), while the one used for cooking food is situated in the courtyard, close to the granaries (about 10m to the North) (Fig.10). The former consists of a thick layer (about 20 cm) of gray ashy sediment that was visible on the surface whereas the latter displays a thinner deposit of ash. The three stones typically used to stabilize the large cooking vessels (*Atieda*) were not uncovered for the hearth related to beer production unlike the one used for food cooking (Fig. 10). They may have been removed for reuse in the neighboring fields still cultivated by inhabitants of the village of Iwol.

4.2. Pottery associated with beer

Ethnographic observations

- Pottery found inside the beer houses

Three main morpho-functional groups of pottery are present inside the beer houses of the different Bedik villages (Andiel, Ethwar, Iwol, Manda Thiès et Ninéfesha). However, their frequencies vary greatly (Fig. 12; Tabl. 2).

1) The large vessels used to cool, store and ferment beer (*Elema*) are the only functional type that is systematically found inside the beer houses (52 vessels in total), although they can vary from 1 to 8 individuals (median at 4). They are placed inside, along the walls of the beer house.

They are conical shaped, with a thick pointy base suitable for sinking into the ground. Their mouth width varies from 38,4 cm to 78,4 cm (median at 54 cm), their maximum diameter from 51,6 and 99,1 (median at 71) Volume ranges approximately from 65 to 360 liters (median at 174,9 liters). The rim is often decorated using a coil with finger impressions (51 out of 52 pots). Sub-groups of this pottery-type (*Nianema*, *Nietede*, *Atwagn*) have been occasionally observed (6 vessels in total) and were only found in three beer houses - one of them having yielded four vessels (*Nianema*). They are similar from a typological point of view to the very large vessels (*Elema*), although they are significantly smaller, between 22,9 liters and 90 liters (median at 64,5 liters) (Fig. 13).

Large vessels used to cool, store and ferment beer (*Elema*) display an over-representation of beer spills and wall crumbling (or spalls/attrition) in a horizontal fashion under the rim (10 out of 17 pots) and/or in the lower body (8 out of 17 pots). Based on their position, the clay crumbling could be induced by the physico-chemical reactions with the corrosive foam and the fermentation. They can be accentuated and/or accelerated by the stirring motions with wooden sticks. They also display a high proportion of broken rims (10 out of 17 pots), which the owners claim happens when a container full of liquid is rested on its rim during the different transfer operations. The smaller versions of this functional type (*Nianema*, *Nietede*, *Atwagn*) display similar beer spills (2 out of 5), broken rims (1 out of 5) and wall crumbling (or spalls/attrition) (2 out 5, located on the upper and mid body) (Fig. 14).

The pots used to cool, store and ferment beer (whether they are *Elema*, *Nianema*, *Nietede* or *Atwagn*) clearly differs from other functional classes of ceramic vessels, both by their shapes (conical profile, slightly closed opening, pointy base, capacity often greater than 100 liters) and their use-traces (numerous outer organic spills, inner wall crumbling) (Mayor and Vieugué, 2017).

2) The vessels used to ferment, transport, and serve beer (*Niene*, *Ide*, *Amband*) are the most common types (69 documented in total). Up to 13 individuals were observed in a single beer house. However, this type of beer pot can sometimes be completely absent inside a beer house which can be explained as the pots are mobile and often lent to other family members or acquaintances. They are usually found near the large vessels used to cool, store and ferment beer and can even be found grouped in piles.

They are globular shaped with a very narrow opening and sometimes a bottle neck. They come in three sizes that are called differently accordingly (*Niene*, *Ide*, *Amband*), correlated to the number of people to serve. Mouth width ranges from 5,4 cm to 11,8 cm (median 7,5 cm) while the maximum diameter is between 15,6 cm and 36 cm (median at 24 cm), so that the rim represents between 20 and 48 % of maximum diameter (median at 33,8 %). Volume is between 2,1 and 21,5 liters (median at 9,9 liters). They can be plain (38 occurrences out of 58 *Niene*) or display decorations such as intricate incisions, grooves, impressions and added clay lumps (20 occurrences out of 58 *Niene*) (Fig. 13).

The pots used to ferment, transport, and serve beer (*Niene*, *Ide*, *Amband*) display organic spills (13 out of 14), broken rims (9 out of 14) and severe wall crumbling (or spalls/attrition), either in the inner upper body (4 out of 14 pots) or incrementally on the entire inner wall except the rim part (7 out of 14 pots). The inner bottom crumbling is so dramatic that some pots are about to break. Similarly, to *Elema*, the fermentation process as well as the friction of the small stirring wooden sticks on the pottery walls may be the combined cause of the wear (Fig. 14).

The pots used to ferment, transport, and serve beer (*Niene*, *Ide* or *Amband*) show differences in terms of shapes (globular profile, very closed mouth, round base, small capacity often lower than

10 liters) and use-traces (numerous outer organic spills, inner wall crumbling), compared with other functional classes of ceramic vessels (Mayor & Vieugué, 2017).

3) The pots used during rites (*kopoot*) are present in quite a large number as soon as there is a “fetish” inside the beer house. They are stored over the stone “fetish”. Interestingly, the beer house that delivered the most ritual pots (MNI 13 items) belongs to a Kamara family who is responsible for ceremonies.

Neither morphometric nor use-wear analyses of these specific pots were carried out according to the wish of the owners. However, we were able to observe they appear in the form of two morphotypes: the first one includes 8-shaped pots with a very restricted opening and highly decorated body; the second one corresponds to plain small bowls. Such ritual pots clearly stand out from the other functional classes of ceramic vessels in the Bedik country (fig. 8).

- Beer pots associated with the hearths

Only one morpho-functional type of pottery is found in association with the hearths used for beer making. These are pots used to cook the malt (*Atieda*) which exists today only in a quite limited number. Often found in one copy per fireplace, they are either placed upright on the three stones of the hearths or placed upside down next to it.

Their shape, size and volume are very similar to the large ceramic vessels used to cool, store and ferment beer (*Elema*). *Atieda* are conical shaped with a thick pointy base. The rim diameter greatly varies between 38,4 cm and 78,4 cm (with a median at 48,3 cm) while their maximum diameter ranges from 51,6 to 99,2 cm (with a median at 62,7 cm). Their capacity is between 66 and 332 liters (with a median at 114 liters) (Fig. 13).

The vessels used to cook the malt (*Atieda*) show, on the other hand, different use-traces compared to that of the pots used to cool, store and ferment beer (*Elema*). They always display outer soot deposits and inner charred residues (6 out of 6), as well as organic spills (6 out of 6). Only 1 pot shows some inner clay wall crumbling. This may be explained by the fact that the fermentation does not take place inside the pot (Fig. 14).

Here again, the large pots used to cook beer (*Atieda*) clearly differ from other functional classes of ceramic vessels, both by their shapes (conical profile, slightly closed opening, pointy base, large capacity over 60 liters) and use-traces (numerous organic spills, outer soot deposits, inner charred residues) (Mayor and Vieugué, 2017).

According to the ethnographic study, three main criteria can be used to differentiate beer pots from other functional classes of ceramic vessels: 1) The presence of a thick pointy base; 2) A capacity of over 100 liters; 3) The presence of clay crumbling (or spalls/attrition).

Archeological data

- Pottery found inside the beer house

At Eguong, several large fragments of ceramic vessels were uncovered inside the beer house. The precise number of such large vessels could not be established but may be between three and six individuals. Some sherds display wall crumbling (or spalls/attrition) on their inner surface (Fig.15). On the most complete pot, they are localized in a horizontal fashion below the interior rim and in spots in the lower inner body. Based on the large size of the pots and the presence of wall crumbling on their inner surface, we can assume that these vessels were used to cool, store and ferment beer (*Elema*).

Only one small globular vessel with a restricted opening was discovered inside the beer house. The pot is decorated with a set of incised triangles and a horizontal line of punches. Almost all its sherds display a severe wall crumbling in their inner surface whereas they show no use-alteration on their outer surface (Fig. 15). The rim also shows traces of chipping. From a morphological and use-wear point of view, this pot can be compared to ethnographic pots used to ferment, transport, and serve beer (*Niene*).

- Pottery associated with the beer cooking area

At Eguong, no pottery sherds were found associated with the beer hearth.

5. Discussion

5.1. Identifying the places of beer production in past Bedik villages

By comparing the ethnographic and archaeological data collected on the buildings and cooking areas of several Bedik villages, we were able to establish the relevant criteria for identifying the different places of beer production within ancient settlements.

Recognizing the beer houses

The ethno-archeological study conducted in the Bedik country clearly shows that the identification of beer houses based only on the architectural remains is highly challenging. The location and the shape of the buildings, as well as the construction materials and techniques of the walls, does not allow us to differentiate them from other structures. At the present-day village of Iwol and the abandoned site of Eguong, the beer houses are located among other buildings. All of them are round shaped, like bedrooms and granaries. Most are made up of earth walls built using cob techniques, such as other buildings. The size of the buildings does not prove to be a more relevant criterion. Indeed, the archaeological beer house uncovered at Eguong is significantly larger than all the ethnographic beer houses recorded at Iwol whereas it should have had similar dimensions given their close link in time and space. It is furthermore bigger than the bedrooms and large granaries of the compound excavated whereas it should have been smaller according to the ethnographic model. This could be explained as the owner of the Sadiaxu family's beer house at Eguong was the most important religious chief of the region and likely chose to build a large beer house to install a large altar inside it. Apart from this altar, the presence of shallow pits surrounded by stones alongside the walls of the buildings is the only diagnostic criteria to differentiate the beer houses from other structures. Two such pits were recognized during the archaeological survey of the Sadiaxu family's beer house at Eguong, suggesting at least the presence of two *Elema*-type vessels inside it. Other pits might not have been identified during the excavation, due to the shallow depth of these structures. Nevertheless, the beer house at Eguong could not have fitted more than 6 large vessels given the available space.

The ethno-archeological study also clearly points that pottery remains found inside buildings might help to identify beer houses in archaeological contexts although their potential obviously depends

on their state of preservation. A limited number of potteries was, indeed, uncovered inside the Sadiaxu family's beer house at Eguong (NMI=4) compared to that of the Keita's and Kamara's family beer houses at Iwol (NMI = 10 to 21). Such a difference can be explained as the complete vessels were likely taken away at the time of the abandonment of the village. Nevertheless, some elements of broken vessels were left inside it. Consequently, the pottery remains coming from the excavated beer house at Eguong (116 sherds) are highly fragmented, making the reconstruction of the shape and size of the ceramic vessels very difficult. At least 3 large and thick pots featuring a décor with finger impressions near the rim and a pointy base, as well as one small and thin vessel with a very restricted opening and incised and punches decoration on the upper body were nevertheless recognized. On the other hand, the pottery remains uncovered inside the Sadiaxu family's beer house at Eguong is quite well preserved, making the reading of use-traces possible. A large amount of them shows severe crumbling on their inner surface. By combining the typometry and use-wear of pottery, we were able to identify Elema and Niene-type pottery.

Identifying the beer cooking areas

Our study clearly shows that the identification of the beer cooking areas based only on the architectural remains is illusive. The shape of the hearths is not at all a diagnostic criterion to distinguish the ones used to make beer from the ones used to prepare food. At Iwol and Eguong, they are identical. All of them are materialized by a thick layer of ash sediment, sometimes associated with three large stones. Only the location of the hearths seems to be relevant to differentiate them. Whether in Iwol or Eguong, the ones related to beer production are in the outskirts of the compounds while the ones linked to food preparation are in the courtyard.

The ethno-archaeological observations carried out on the cooking areas of several Bedik villages show that pottery remains are barely more informative for identifying the hearths used to boil beer. At Eguong, no sherds were identified in association with the excavated hearth linked to beer production. This is not very surprising given the limited number of *Atieda*-type pots found close to the hearths in Iwol, often re-used as chicken houses. Such a complete absence in Eguong can be explained as the complete beer cooking vessels were likely taken away, and the sherds of the broken ones disposed of in dumping zones far from the compound.

This study clearly demonstrates the difficulty in the identification of the different places linked to beer production in archaeology, at least in the Bedik context.

5.2. Beyond the Bedik country: Beer production in Africa

The data collected on the Bedik beer houses and cooking areas are here compared with other cultural groups throughout Africa to assess the transcultural value of the criteria established to identify the different places of beer production. As no studies have been carried out with the same objectives as ours, it was not possible to make systematic comparisons on all criteria. Scarce investigations are informative on the places of beer production (Seignobos 1982; Eguchi 1975) or the material culture related to beer production (Arthur 2002, 2003, 2012; Barreteau and Delneuf 1990; Bedaux 1986; Gallay et al. 2012; Fowler 2006). But some major works have focused on the social significance of beer production and consumption and mention such data (Jolly 2004; Müller-Kosack 2003; Eguchi 1975; Van Beek 1978; 2002). Scarce as well are the studies interested in beer production in the archaeological record of sub-Saharan Africa (Langlois 2005; Dueppen and Gallagher 2021).

As a first approach, we chose to compare the context of the Bedik country with the Dogon in Mali, the Tora in Burkina Faso, the various people living in the Mandara mountains and highlands of Northern Cameroon, the Gamo in Ethiopia, and the Zulu in South Africa. Although culturally, linguistically, and spatially distant, these groups all have in common the production of beer by malting cereals like millet, sorghum, maize, wheat or barley, and the consumption of this fermented beverage as an integral part of their cultural identity, survival economy and religion (Berger 2022). Beer is indeed often drunk during field collective work, seen as payback for voluntary labor, and during feasting, being always a collective activity and a deep social binder (Dietler 2001; Hunter 1979; Netting 1964; Watson 1998).

The Dogon (Central Mali)

In the Dogon country, beer produced during collective rites may involve a grinding stage localized either in a public square of the village, or in a courtyard (Jolly 2004:274). Cooking can take place in the courtyard of the compounds, or in kitchens (especially for preparing ritual beer), or in shelters in front of the quadrangular houses. Not all compounds have a place to brew beer (Jolly 1995: 182). The hearths used to cook beer are built at the foot of walls to refract heat, shelter from wind, and use less wood (Jolly 2004: 59). They are made of large stones, or mud feet, planned to set three or four large vessels depending on the regions (Jolly 1995: 181). They are like the ones used to cook food but have larger feet or stones. Fermentation jars are often set in the ground.

In the Dogon country, there are several different ceramic traditions, produced by potters belonging to various endogamous blacksmith groups, or by potters who are farmers' wives (Gallay et al. 1998). This has an influence on the techniques used, the types of vessels produced, and the morphologies obtained. In Tireli (tradition A), Bedaux (1986) describes two groups of beer-making pottery. The first group comprises spherical pottery of varying sizes, with a wide opening. Three vernacular terms are used to distinguish them: firstly, those for cooking beer; secondly, those for storing beer; and thirdly, those for storing beer, fermenting beer, or storing other foodstuffs. The second group comprises narrow-mouthed spherical pottery of varying sizes, with three vernacular terms distinguishing the types, all related to the "storage" of beer. This term is probably too vague to really understand the role of these pots.

E. Jolly (1995: 187) specifies the different types of pottery used to make beer, combining several traditions: 1. hemispherical fermentation jars, large with very wide openings. They have a volume of between 100 and 200 liters; these are the largest pottery, both in height (43-48 cm) and maximum diameter (58-62 cm); the more variable opening diameter (32-62 cm) overlaps that of other categories such as water storage jars (Gallay et al. 2012: 188). 2. cooking jars, spherical, slightly ovoid, with a slightly closed opening, and a capacity of 25 to 35 liters; 3. pottery for transporting or serving beer, of medium size and with a slightly closed opening, into which beer is drawn with a calabash. There are also narrow-necked pots used to pour beer directly into drinking calabashes. In the village of Diallassagou, such small, narrow-necked pots, containing from 33 to 66 cl of beer, are used to measure beer for sale; 4. Ritual pots containing a man's share of the beer, 3-4 liters, or an ancestor's, smaller and more open. They are placed in a small room in the house and filled with beer every year; 5. Libation dishes, 4-5 cm in diameter, embedded in a wall or in the clay of an altar, in which offerings of food and unfermented beer are made. It is worth noting that such very small plates were discovered during the archaeological excavation of the Dangandouloun rock shelter, occupied between the 7th and 11th centuries AD and used for ritual purposes (Mayor 2011: figs. 100, 111, 113, 126).

No use-wear studies have been carried out, but E. Jolly mentions that the bottom of beer cooking jars is covered with a layer of plaster to prevent cracking during the long wort cooking process.

The Tora (Mouhoun Province, Burkina Faso)

S. Dueppen and D. Gallagher (2021) mention the use of permanent installations to cook beer, which consist of earthen structures to elevate the pottery vessels above the fire and fix them. The fermentation is processed in heavy vessels that are embedded in the ground in a permanent setting as well. There is no mention of specialized buildings, and beer seems to be cooked and brewed in the open air.

These researchers have documented 3 types of pottery involved in the current production of beer:

1) Cooking vessels with an open mouth and a slightly restricted neck and an outturned flared rim. They are described as larger than cooking pots, except when large batches of millet porridge is needed.

2) Large brewing vessels that are open and unrestricted, with thick walls and coarse fabric, which can be paralleled with the Bedik vessels used to cool, store and ferment beer.

3) Small open bowls used to cultivate the yeast. Bedik beer processing does not need voluntary incorporation of yeast and relies solely on the yeast trapped in the porosities of the clay matrix. As everywhere, calabashes are used as drinking vessels.

Use-wear was not studied in this context.

People of the Mandara mountains and the highlands (Cameroun)

In northern Cameroon, the spatial distribution of the various stages in beer production varies from one cultural group to another (Seignobos 1982). While the notions of hut-brewery and kitchen-brewery are mentioned most of the time, it is not always clear whether wort boiling takes place inside these buildings or outside, in the adjoining courtyard. In addition, the hearths are almost never described, and the beer-making process is rarely detailed in terms of the spaces. Finally, references to beer-making pottery are often imprecise or ambiguous as to their function.

Despite these limitations, it is possible to gather information on the spatial organization of beer production. In most cultural groups, beer brewing takes place in one or more buildings dedicated solely (hut-brewery) or in part (kitchen-brewery) to this activity. The situation can be complex, with parallel production, as with the Kapsiki, of beer for ceremonies, prepared by the men, as distinct from beer for domestic consumption and market sale, made by the women. This translates into multiple and distinct brewing spaces within the compound, one in a hut-brewery dedicated to the chief, located at the very back of the compound, and the others in the kitchens used by the women of the polygamous family, adjoining their bedrooms (van Beek 1978; Seignobos 1982: 105).

The wort is cooked either in specialized huts or brewery kitchens, or in the adjoining courtyards. In Mofu kitchens, it is noted that the hearth for cooking food is at the back of the room, opposite the entrance, and that there is exceptionally a larger hearth for brewing beer (Seignobos 1982: 42). Among the Mafa, a fireplace may be set up during the dry season in the courtyard adjoining the brewery-kitchens, near the dregs filter, consisting of a large basket on trestles (Seignobos 1982: 78).

While these brewing buildings are usually located inside the compound, they may more rarely be found outside, near the entrance. Sometimes, as is the case with the Koma, an apparatus of three jars for cooking the wort may be installed outside the village, near a stream where the millet is immersed in closed baskets before being put to germinate (Seignobos 1982: 162). The Hide also sometimes brew beer directly in their terraced fields (Eguchi 1975).

The compounds also have other areas dedicated to beer production. Among the Mafa, sprouted sorghum is dried in a special roofed area near the goat shed (Müller-Kosack 2003). Among the Hide, once brewed, the beer is taken to the ancestors' hut, where it is stored, used for libations, and served in the courtyard using calabashes (Eguchi 1975).

In terms of size and building materials, brewery huts are not systematically distinguished from functionally different buildings. Variations in construction techniques may exist between huts, but these are more related to social aspects, as in the case of the Kortchi, where buildings for men, including beer huts, are built with alternating beds of stone and clay, while those for women are made entirely of earth (Seignobos 1982: 104).

Finally, the internal layout of a brewery depends very much on the nature of the building. Kitchens are characterized by the presence of a grinding table (two to five millstones set into a low clay wall), a hearth and numerous ceramics, including beer jars. The cumbersome filters seem to be located most of the time outside, in the courtyard adjoining the kitchen. In the case of brewery huts, there are essentially a few large brewing jars and smaller ones for transport. It is often mentioned that the large brewing jars are buried in the ground, as with the Kapsiki (Seignobos 1982: 106).

Concerning beer containers, two or three different types of pottery are generally distinguished, not counting ritual pottery used for libations. Eguchi (1975) mentions in the Hidé kitchens the presence of one or two large jars, 70 cm high and 60 cm in diameter, for brewing and fermenting beer, kept with filters and calabashes on shelves on stakes, next to the stone millstones. In the ancestors' hut, there are medium-sized jars with round bases and narrowed necks, plugged with leaves, with a capacity of 15 to 20 liters, for storing beer near the ancestors' altar. Finally, there are small, tightly sealed 3-4-liter jars for serving beer in calabash bowls, where it is drunk. Among the Kapsiki, there is also mention of large jars for brewing beer, complemented by small narrow-necked jars, plugged with leaves, for cooling and fermenting the beverage (van Beek 2002). Among the Mafa, Müller-Kosack (2003) shows a photograph of a pottery with a round base, a very narrow opening, an everted rim and one handle, used for fermenting and serving beer in bowls made of calabashes. Finally, according to the two ceramic plates in Barreteau and Delneuf's (1990) article on the comparison of pottery and words among the Mofu and Giziga, no distinction is made between jars for transporting water and beer, which are generally very closed (e.g., 47 cm high, 42 cm diameter and 8 cm internal diameter at the opening) and feature a handle under the neck or two nipples for gripping. Jars for storing water are also indistinguishable from those for "preparing" beer, whose shapes are variable, but some are very large, e.g., around 90 cm high, with a diameter of around 60 cm and an internal diameter at the opening of 50 cm.

No studies have been carried out on use-wear, but Barreteau and Delneuf (1990: 135) mention that large fermentation jars can be doubled in thickness with a film of unsmoothed clay, to reinforce their resistance.

The Gamo (Ethiopia)

Among the Gamo, beer processing occurs within specialized kitchens and storage buildings (Arthur 2003: 523), which can only be found in the wealthiest households.

Two types of pottery are used to produce and drink beer: 1) Large jars (33.6 liters on average, N= 52, min 2.8, max 124.7; Arthur 2003: 522) that are globular shaped, have a restricted opening and a neck. They seem to be used both for cooking the malt and fermenting. The author specifies that jars are made into five different sizes with each their own function, and the largest jar is used for beer; 2) a special size jar, smaller than the previous one, is used specifically to be carried out into the field.

To our knowledge, J. Arthur has conducted the only use-alteration study on African beer pots. He has demonstrated the link between fermentation and inner surface crumbling (or attrition/pitting) of all fermentation vessels (Arthur 2002, 2003), even though stirring sticks are not used, and different clays are exploited (Arthur 2003: 524).

The Zulu (South Africa)

Beer production in Zulu society has been investigated by K. Fowler (2006, 2011), who has focused his work on ceramic classification and not on the locations of the production. It is just mentioned that brewing jars can be found at the back of circular houses and are often partially embedded in the floor (Fowler 2006: 99), as was repeatedly observed in the different regions in focus. It is not mentioned where the malt is cooked.

According to Fowler's classification of Zulu ceramic vessels, four main types of pottery are used at different stages of the beer production process (Fowler 2006: 98):

1) Pots used to cook and brew beer: very large vessels with a restricted rim and a conical bottom. They come in different sizes and proportions with an average between 44 and 56 cm in height depending on regions (Fowler 2006: 99). These shapes are used for either cooking or fermenting the malt, it is not mentioned whether the same pot may be used for both or if each is specialized. From a morphological standpoint, they are very similar to the vessels found in Bedik country (*Elema*). According to the author, smaller shapes are used for the brewing of beer while large shapes are only used for special occasions.

2) Vessels used to serve beer. They are globular shaped pots with a restricted rim and are distinguished by size and called accordingly. They are on average more than 25 cm, 20 cm and 15 cm in height depending on the size category (large, medium, and small). The smaller version of the pot can have an alternative ritual function. 3) Pots used to store and serve beer. They are globular shaped pots with a very restricted rim and are wider than they are tall. They range from 30 to 40 cm in height. They are so heavy that smaller vessels are typically used to draw beer until the pot can be lifted. They are only used for special occasions with large gatherings (Fowler 2006: 101). The same shape can be used to store water. 4) Pots used to transport beer. They are used to "store and transport water or beer to work parties in the field or homestead" (Fowler 2006: 102). They are globular shaped with a neck and some vessels classified in a subgroup can sport multiple spouts. They vary greatly in size (between 14 and 43 cm in height).

No use-wear analysis was carried out on the Zulu pottery assemblages.

Synthesis

The location of beer-making facilities varies widely from one group to another. Wort boiling and brewing may take place in specialized buildings used exclusively for this function (Mandara), or in kitchens that allow this activity (Dogon, Mandara, Gamo, Zulu). It may also take place outside, usually in the compound's courtyard (Dogon, Tora? Mandara). Cooking may even happen on hearths located outside the compound (Bedik, Tora, Mandara). Beer brewing may take place in all homesteads (Mandara, Bedik) or only in some (Dogon, Gamo). The beer hearths are most often like the food cooking hearths, sometimes a little larger (Dogon), but sometimes differ in that they feature a permanent clay construction incorporating the cooking jars (Tora). When there is a beer hut, it is generally indistinguishable from the other buildings used for other functions, whether in terms of materials, techniques, or dimensions. The only recurring design element in all cultural groups is the presence of small pits to hold the large brewing jars, to stabilize them.

As far as ceramics are concerned, all the groups have several types of vessels used in beer-making, each with very different shapes and sizes. Some groups cook the wort and ferment the beer in different jars (Bedik, Dogon, Tora), while others use the same jar for both stages of production (Mandara, Gamo, Zulu). All these containers are large, hold a significant volume of liquid, and feature either very wide (fermentation jars) or slightly closed openings (cooking jars). Fermentation jars, with a capacity of 100 to 200 L., are very similar among Bedik, Dogon and Tora. Their bottoms are thick and often conical, generated by the roughout technique, or reinforced by the addition of a layer of clay (Dogon, Mandara), to resist thermal shock during the long firing. Except for the Tora, all groups also have jars for transporting and serving beer, which hold a few liters and have very narrow openings, even plugged with leaves. These containers allow fermentation to continue and are even sometimes used as fermentation boosters.

Some groups also use medium-sized (15-20 L.), narrow-necked jars for storing beer (Mandara), or small containers for storing yeast (Tora). Several also have ritual vases with very particular shapes and decorations, on which beer libations are performed (Bedik, Dogon, Mandara). In the only two contexts where use-wear have been studied (Bedik, Gamo), the vessels in which fermentation took place show characteristic internal attrition. Inner surface crumbling can therefore be considered as an indicator for beer production, but it remains to be clarified if other contents can cause similar alteration. The difference with other fermentation mechanisms or fermented foodstuff may need to be addressed in the future. Finally, all groups drink their beer from calabash bowls.

In short, while architectural elements are not discriminating in cross-cultural terms, apart from the pits used to house the large fermentation jars, which are probably often difficult to identify during archaeological excavation, some elements may be relevant locally, such as the clay structures used to cook beer among the Tora, or the codified location of beer huts within the habitat of certain groups in the Mandara Mountains. In fact, the best identification criteria concern pottery, particularly very large open jars used to cool, rest and ferment beer (*Elema* type), and small to medium-sized ceramic containers with very narrow openings used to ferment, transport, and serve beer (*Niene* type), even more so if they show internal crumbling linked to the fermentation process.

6. Conclusion

Given the difficulty of finding evidence of beer production in Sub-Saharan Africa's past outside the Nile valley, and the scarcity of studies focusing on spatiality and materiality of beer making, our ethno-archaeological investigation aimed at offering a clue to help assess the production of beer in the archaeological record. It was conducted in several villages of the Bedik Country in south-eastern Senegal, where people still produce beer by malting mainly sorghum.

Our study considered the ethnographic context, as well as the archaeological one, with the excavation of a ruined compound in the abandoned Bedik village of Eguong. Different aspects were considered to offer a comprehensive view: the "chaîne opératoire" of beer production, the architecture (locations of production stages, shape, technique, and dimensions of buildings), and associated material culture. Pottery vessels were analyzed combining morphometrical and use-alteration. Finally, a comparison of our observations in the Bedik country with other ethno-linguistic contexts in western, eastern, and southern Africa, chosen from among the best documented, enabled us to distinguish between criteria that are recurrent and transcultural, and those that are variable, linked to each culture, and therefore not useful for interpretation beyond direct analogies within a given cultural group.

The detailed documentation of the Bedik “chaîne opératoire” of beer production brought significant information regarding location, duration, quantities, ingredients, gestures, and tools, shedding light on the complexity of this practice. The exhaustive inventory of material culture found inside 14 beer houses and 6 beer cooking hearths has delivered important data regarding organic utensils and containers involved in the production, as well as the different types of ceramic vessels related to beer production.

The analysis of architecture shows that the beer houses cannot be distinguished from other domestic buildings (bedrooms and granaries) from a locational, morphological, and technical point of view: they are all found inside a compound, round shaped, and mainly built using earth (cob technique), sometimes wattle. But the inner organization of beer houses systematically feature shallow pits and stones used to stabilize large beer vessels, contrarily to other buildings.

Better than architecture, material culture associated with beer production offers a convincing framework for the identification of beer, even if organic artifacts are not preserved. Ceramic morphology (high-capacity vessels and small set with narrow opening) combined with use-alteration observations have the potential to evidence beer production. In conformity with John Arthur’s research in Ethiopia, our use-alteration study has further demonstrated the link between fermentation and inner wall crumbling. In the absence of fermentation, vessels used to cook the malt show almost no similar wear, while carbonized residues and soot deposits are systematic.

The excavation of a Bedik compound including a beer house and a beer hearth in Eguong has shown the difficulty to interpret the archaeological record even with a very small spatial and temporal distance, due to the unexpected variability of certain criteria given the special status of the past owner as important religious chief, and the loss of certain key objects, probably re-used, like beer pots or hearth’s large stones. Nevertheless, both main categories of beer pots and a huge altar have been recognized in the beer house.

Finally, the comparison with several very distant current cultural contexts in Mali, Burkina Faso, Cameroon, Ethiopia and South Africa, has confirmed that the best transcultural identification criteria for beer production concern pottery, particularly the very large open jars used to cool, rest and ferment beer, and the small to medium-sized ceramic containers with a very narrow opening used to ferment, transport and serve beer, all the more so if they show internal crumbling linked to the fermentation process.

This preliminary ethnoarchaeological investigation about beer recognition in African archaeology combining different proxies has no equivalent so far. It should be completed to offer stronger data and should be replicated in different cultural contexts to better grasp the constants and variations in beer recipes, architecture, material culture and use-alteration traces. Another perspective is to cross these criteria with the ones coming from chemical and botanical analyses on organic residues in pottery, a study in progress (Drieu et al. 2022).

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Disclosure statement

The authors report there are no competing interests to declare.

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Tables

Tabl. 1: Quantification of the different types of containers and utensils found inside the 14 Bedik present-day beer houses documented.

Tabl. 2: Quantification of the different morphotypes of pottery found inside the 14 Bedik present-day beer houses documented.

Figures

Fig. 1: Location of the visited Bedik villages in South-East Senegal.

Fig. 2: Location of the different places of beer production inside a Bedik compound (pictures come from different compounds).

Fig. 3: Beer houses plans and inner spatial organization.

Fig. 4: Manufacturing process of beer among the Bedik. a) Malting, b) Brewing, c) Fermentation. Pottery vessels are colored while organic, plastic and metal containers are shown in outlines.

Fig. 5: Location of beer houses inside Bedik compounds (After Pelmoine 2020, modified).

Fig. 6: Surface area of beer houses (left), bedrooms (center) and granaries (right) in present-day Bedik villages (Iwol, Ethwar, Andiel, Manda Thiès, Ninfesha, Indar).

Fig. 7: Building materials and techniques of beer houses (top), granaries (middle) and bedrooms (bottom).

Fig. 8: Inner layouts of present-day beer houses: (a) shallow pit used to maintain large ceramic vessels; (b) Altar.

Fig. 9: Example of cooking areas in Bedik present-day villages: (a) hearth used for beer (Iwol); (b) hearth used to cook meals (Andiel).

Fig 10: View and plan of the beer house and cooking area excavated at the abandoned compound of Eguong.

Fig. 11: Surface area of the beer house (left), bedrooms (center) and granaries (right) included in the Sadiaxou family's compound of Eguong.

Fig. 12: Frequency of pottery morphotypes found inside beer houses.

Fig. 13: Morphometrical diagram of pottery per morpho-types.

Fig 14: Typical use-alteration of beer pots.

Fig. 15: Large (*Elema*) and small (*Niene*) vessels from the site of Eguong displaying inner wall crumbling.